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Wireless networking

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Some characteristics of RF signals

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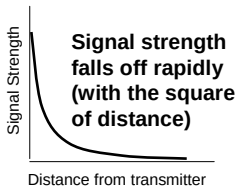
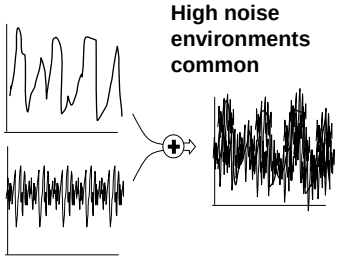
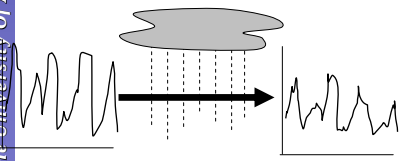


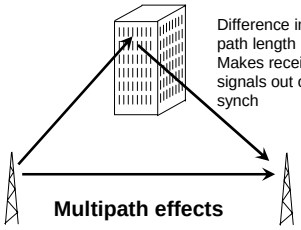
Signal strength falls off rapidly (with the square of distance)



High noise environments common



Susceptible to weather effects



Difference in path length Makes received signals out of synch

Multipath effects

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One of the problems with deploying wireless systems

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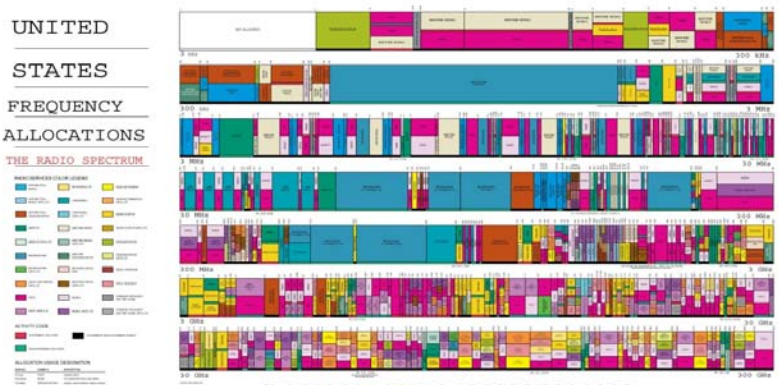

Most frequency bands are unavailable or require users to have licenses.

The few unlicensed bands are very crowded and have limits on broadcast power.

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Mobile IP

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Integrating mobile devices into the wired network

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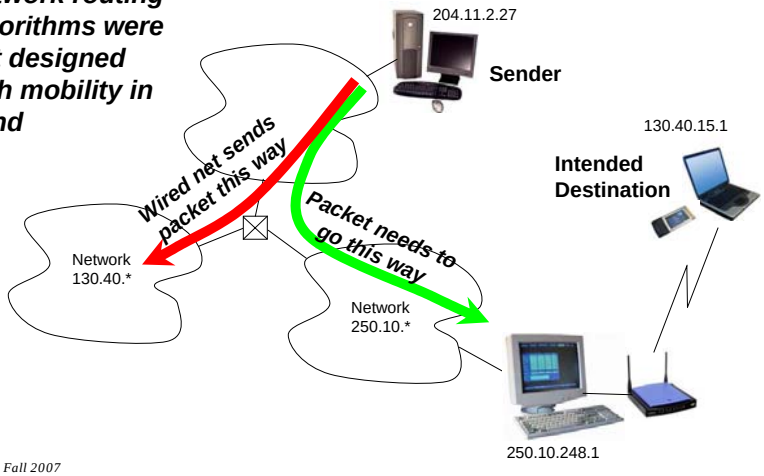
A Problem: Network routing algorithms were not designed with mobility in mind



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The Home Agent

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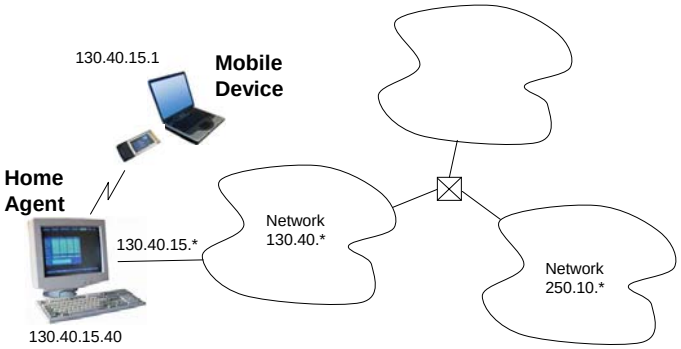
When the Mobile Device is first configured, it is set up with an IP address that belongs to a specific (wired) LAN. A computer on this LAN is assigned to be the device's "Home Agent"



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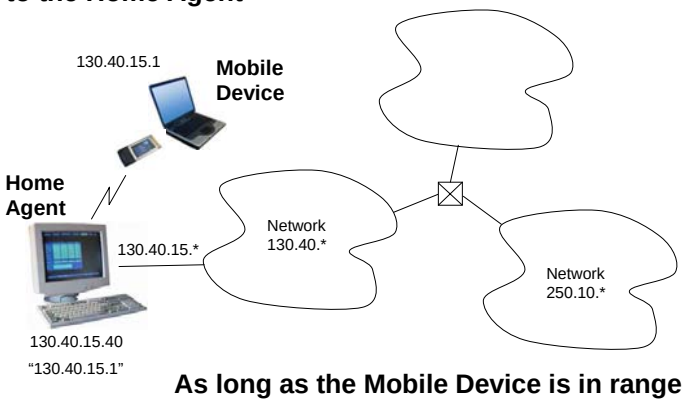
"Stealing" the device's IP address

The Home Agent sends out ARP messages to associate the Home Agent's MAC address with the IP of the Mobile Device. This means that any traffic for the Mobile Device will be sent to the Home Agent



As long as the Mobile Device is in range of the Home Agent, traffic can be forwarded normally

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Reconnecting after a move

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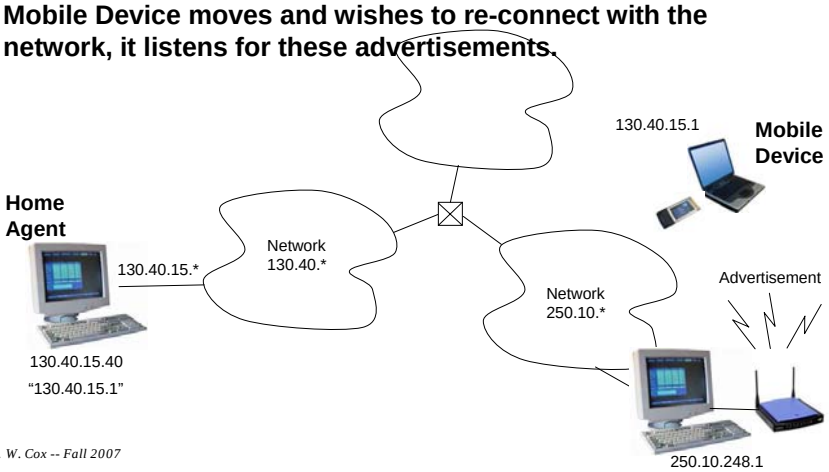
Wireless Access Points that are willing to accept connections from mobile devices advertise that fact by periodically broad-casting their presence and their L1 & L2 parameters. When the Mobile Device moves and wishes to re-connect with the network, it listens for these advertisements.



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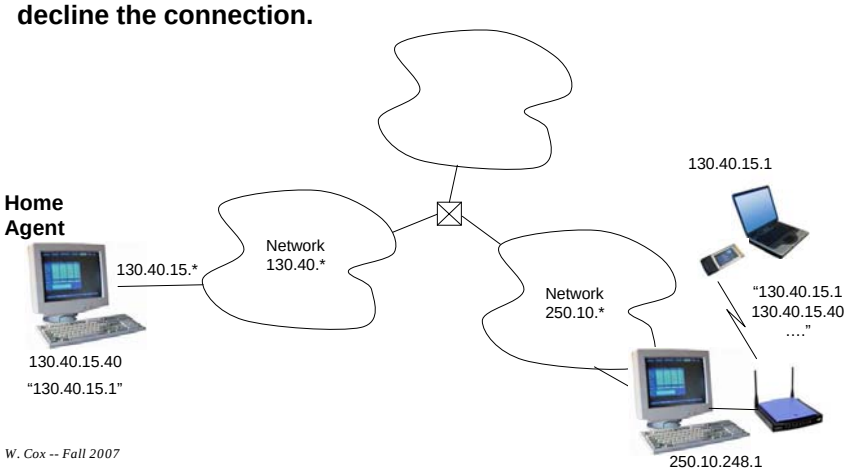
Negotiating with the Access Point

The Mobile Node passes its IP address, the address of its Home Agent, Authentication info, and other identity info to the Access Point. The Access Point may decide to accept or decline the connection.



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Becoming the Foreign Agent

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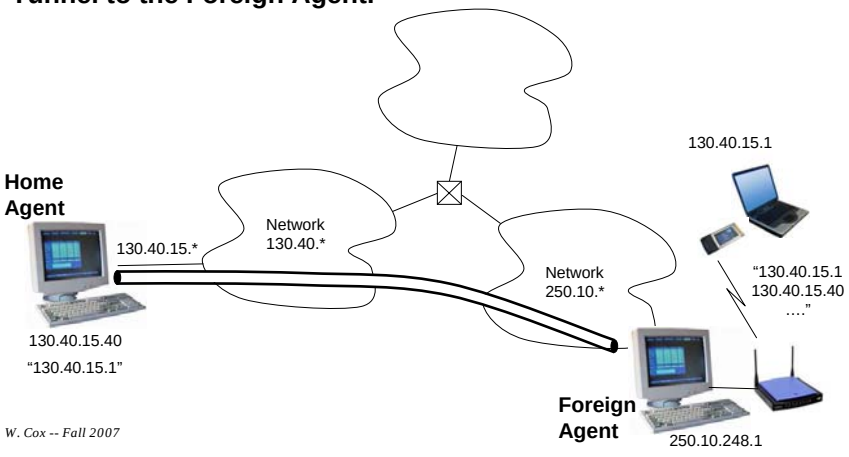
The Access Point communicates with the Home Agent. If they negotiate successfully, the Access Point becomes the "Foreign Agent" for the Mobile Device. The Home Agent sets up an IP Tunnel to the Foreign Agent.



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Forwarding traffic (1)

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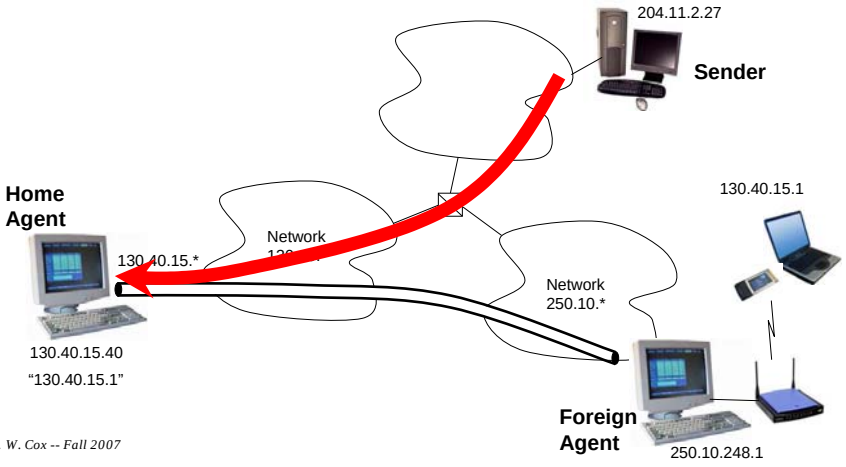
Traffic to the Mobile Device is addressed as usual using the device's IP address. The wired infrastructure passes it to the Home Agent…



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Forwarding traffic (2)

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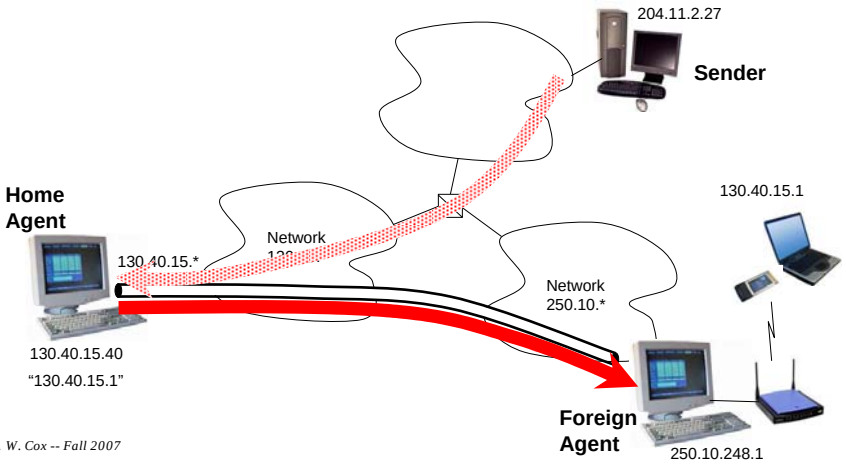
…the Home Agent tunnels the traffic to the Foreign Agent…



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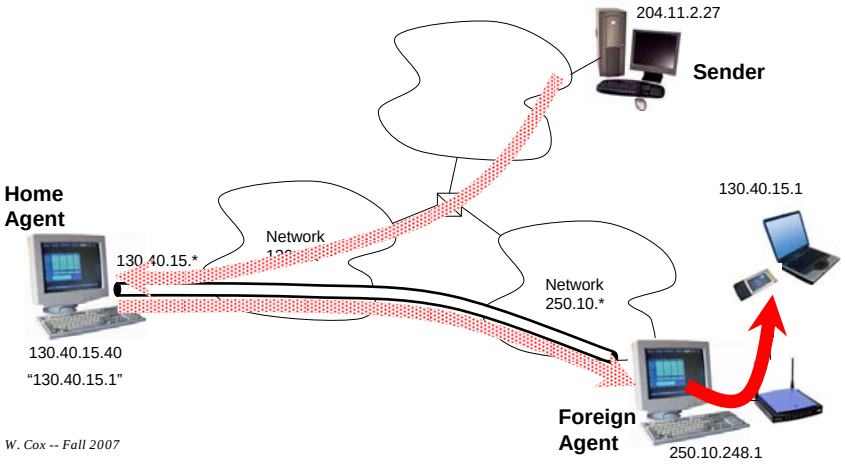
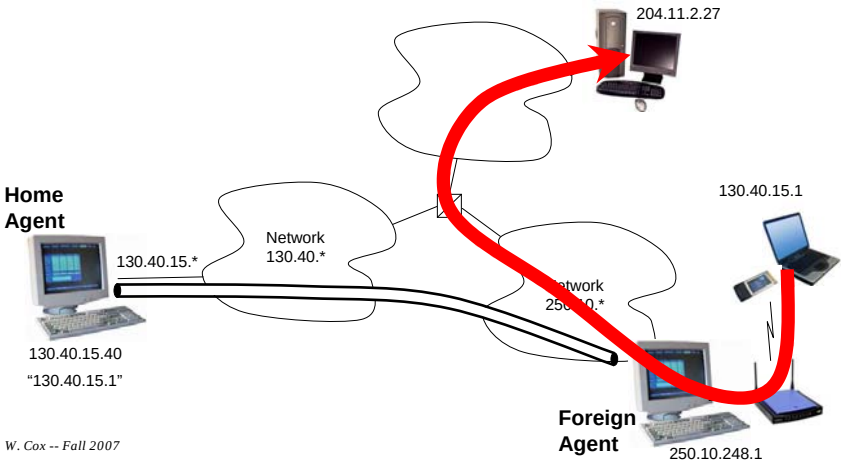
Forwarding traffic (3)

…and the Foreign Agent forwards the traffic to the Mobile Device.

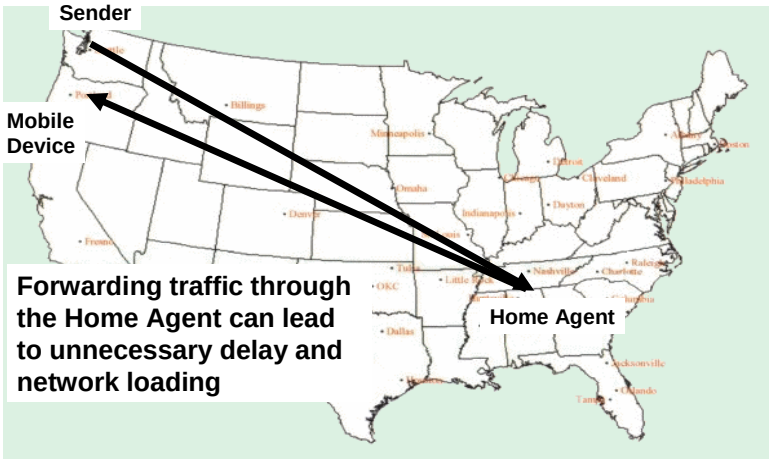


Traffic sent by the Mobile Device

The Mobile Device sends traffic in the usual manner. The wired infrastructure will forward it using normal IP addressing



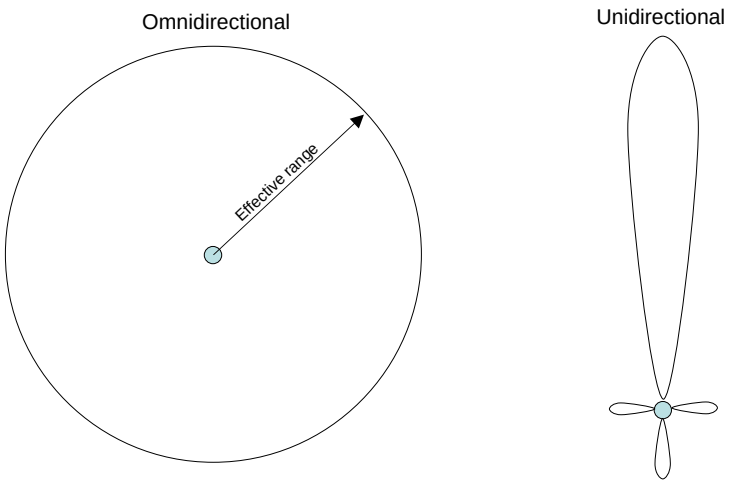
The Triangle Routing Problem



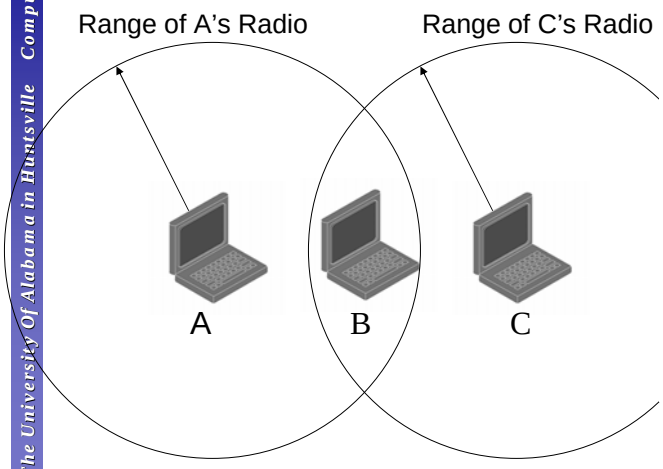
A possible solution to the Triangle Routing problem

- Home Agent gives sender “care of” address (address of Foreign Agent)
  - Problem: possible security hole

Antenna types



The Hidden Node Problem



The Problem:
A and C cannot hear each other's transmissions, so they can't tell when the other one is transmitting.

If both transmit at once, B will hear interference.

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An overview of some wireless modulation techniques

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L1: Modulation techniques

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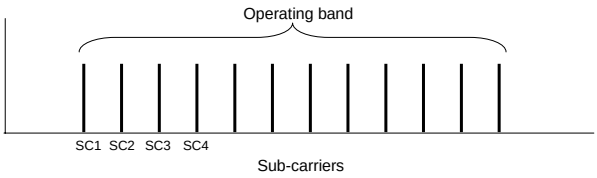
- Frequency-hopping Spread Spectrum modulation (FHSS)
- The general idea: Instead of broadcasting on a (constant) narrow frequency band, hop around among frequencies across a wider band
  - Advantages:
    - Better noise tolerance
    - Better security
    - Less interference with other users



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A problem with FHSS

Need to synchronize the transmitter and receiver so that they are on the right subchannel at the same time

BUT:

An adversary shouldn't be able to easily predict the hop sequence

Pseudo-random sequences

To an observer, the sequence appears random, but the entire sequence can be generated given known parameters and a common "seed" number

Example:

$x_{next} = (x_{current} * C_1 + C_2) \bmod 2^y \quad (X_0 = \text{seed})$

By using the same variables and dwell times, and synchronizing the sequence start, the sender and receiver will stay on the same frequency

802.11 FHSS

- Signal hops between 79 1-MHz channels
- Pseudorandom number generators synchronize nodes
- Time spent in each channel ("dwell time") can be varied (but <= 400 msec)

CDMA: Code Division Multiple Access

- The idea: Instead of dividing up the freq band between users, give each user the the entire band
- Encode signals so that they can be separated (and other signals look like noise)

CDMA: Code Division Multiple Access (2)

- Divide each bit time into m short intervals ("chips")
- Typical m = 64-128 ("chipping rate")
- Each transmitter gets a unique m-bit code ("chip sequence")
- To send "1", send chip sequence
- To send "0", send complement

Orthogonal Frequency Division Multiplexing

- The transmitter separates the data stream into a number of lower-rate data streams, which it then sends over multiple subchannels at the same time.
- Improved resistance to narrowband interference and multipath effects

Multiple-Input / Multiple-Output (MIMO)

- The transmitter transmits over multiple antennas at the same frequency at the same time.
- At a distance, the signals are sufficiently different (e.g., different phase due to different path lengths) that the receiver can sort them out.